

EFFECTS OF INDUSTRIAL SLUDGE WASTE ON GROWTH AND YIELD OF BRINJAL CROP (*SOLANUM MELONGENA L.*)

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ABSTRACT

The present study on “Effect of Industrial Sludge Waste on the growth and yield of Brinjal crop (*Solanum melongena L.*) indicate that the ISW of the Oil and Gas industry, Kakinada. The Industrial Sludge Waste (ISW) collected at the outlet of the release channel of the “Oil and Gas Industry” at Kakinada, was air-dried and brought to the laboratory for the analysis of its physico-chemical characteristics. The seeds of one variety of (Brinjal) *Solanum melongena L.* were tested to evaluate their sensitivity to ISW water extract. However, the germination success in Brinjal declined steeply with the increased concentrations of the WE. The percent of seeds germinated has declined from 99% in the Control to as low as 53% in WE₄. The Industrial solid waste recorded high concentrations of Copper (20.89%), Zinc (16.50%), Iron (9.842%) and Manganese (0.310%). Due to Heavy metal concentration (Brinjal) *Solanum melongena L.* seed germination, plant growth and yields were affected.

KEYWORDS: Atomic, Absorption, Spectroscopy, (AAS), Growth, Heavy, Metal, *Solanum melongena L.*, Yield

INTRODUCTION

Brinjal (Eggplant) (*Solanum melongena L.*) plant species is one of the most commonly grown vegetable crop of Solanaceae family [1]. *Solanum melongena L.*, species is a member of the Solanaceae family, grown extensively in central, southern, and southeast Asia, and in a number of African countries [2]. The problems relating to disposal of industrial solid waste are associated with lack of infrastructure and technology facilities in the industries to take proper safeguards methods. Heavy metal contamination of soil results from anthropogenic such as mining [3], smelting procedures [4] and agriculture [5] as well as natural activities. Chemical and metallurgical industries are the most important sources of heavy metals problems raising in the environment [6]. Heavy metals get accumulated in time in soils and plants and can have a negative influence on physiological activities of plants determining the reductions in plant growth, dry matter accumulation and yield [7] [8]. Some major heavy metals are Zinc (Zn), Copper (Cu), Iron (Fe) and Manganese (Mn). Eggplant had the highest levels of Mn, Pb, and Zn [9] [10]. The biggest concentration of Cd into the plant tissue was observed in the leaves [11]. The heavy metals in lower concentrations are provides nutrients for plant growth, its continual use over extended periods can result in the accumulation of heavy metals in soils and in the crops to levels that are detrimental to the food chain [12]. Risk for human health may be then occur through consumption of such crops and intake of contaminated waters. Its long term use can also cause a significant accumulation of Zn, Cu, Pb, Ni and Cd in the soil and plants [13]. Contamination of soils by potentially toxic elements (e.g. Zn, Cu, Ni, Pb, Cd) is subject to strict controls within short period of time in relation to total permissible metal concentrations, soil properties and intended use. In view of the above, the present study has been designed with the following objectives.

- To assess the pollution potential from the solid wastes of industry.
- To study the impact of industry solid waste on.
- Growth and morphology of *Solanum melongena* L., (Brinjal).
- Cultivated soils.

STUDY AREA

The Kakinada city is under district of East Godavari of Andhra Pradesh on the central east coast of India. Kakinada is situated between the latitude of 16°57' North and longitude of 82°15' East. The study was carried out Industrial Solid Waste applicable and observe the *Solanum Melongena* L. plant growth and yield.



Figure 1: Location Map of the Study Area

MATERIALS & METHODS

The Industrial solid waste samples were collected at the outlet of release channel of the Oil and Gas Industry at Kakinada, air-dried and was brought to the laboratory. The dried material was powdered in a mortar. This was herein after referred to Industrial Sludge Waste and was used for all experiments after analyzing for various Physico-chemical parameters.

Soil

Soil from the conventional crop fields near the Oil and Gas Industry (East Godavari District, Andhra Pradesh, Kakinada) was selected and used in the experimental studies on Brinjal. Soil samples were collected randomly from the field in five replicates and air dried for 72 hours, powdered, sieved through 2 mm sieve and subjected to Physico- chemical analysis.

Industrial Solid Waste

The Industrial solid waste samples were collected at the outlet of release channel of the Oil and Gas industry at Kakinada; air-dried and was brought to the laboratory. The dried material was powdered in a mortar. This was herein after referred to Industrial Sludge Waste and was used for all experiments after analyzing for various Physico-chemical parameters.

Seed Material

The seeds of (Brinjal) *Solanum melongena* L. variety were procured from an Agricultural Cooperative Centre at Kakinada, East Godavari district, Andhra Pradesh.

Preparation of Solid Waste Extract

The Solid waste was powdered and 1 kg solid waste was mixed with one litter of double distilled water and stirred continuously. The water extract of the solid waste was analysed for various physico-chemical parameters.

Germination Experiments

Although pot experiments on the growth and yield of (Brinjal) *Solanum melongena* L. were conducted with the amended soils, the germination performance of the seeds of *Solanum melongena* L. was tested following the method described by Carley and Watson [14] with the water extract of the Solid waste. This is mainly because of the fact that the germination process is relatively rapid process in petridishes culture when compared to soil. The water extract of the solid waste extract was thoroughly hand shaken before experimental use. Graded concentrations of the water extract of the solid waste were prepared using the distilled water as diluent. For each experiment, 25 seeds of Solanum were taken in sterilized petridishes (15×20 cms) at equal distance. These were treated with equal doses of different concentrations (V/V) of water extract of the solid waste (5%, 10%, 30%, 50%) as and when necessary. Seeds treated with distilled water were maintained as control. Four replicates were maintained for each treatment including the control. The petridishes were kept under diffused light at room temperature ($28 \pm 1^\circ\text{C}$). One-week-old seedlings in experimental pots were used for measurement of seedling growth (root and shoot). The dry mass of shoot and root was recorded from 7 day-old seedlings after keeping them in an oven at 80°C for 72 hr.

Pot Experiments

All the experiments pertaining to the pot culture were conducted in the experimental farm of the Department of Civil Engineering, Jawaharlal Nehru Technological University, Kakinada.

Preparation of the Soil Amends for Pot Experiments

The solid sludge was powdered and mixed with black soil and farm yard manure in the ratio 2:1, placed in 15kg pots in different concentrations (5%, 10%, 30% and 50%). The pots were watered with tap water at the rate of 2 l /pot/d. In each pot seeds were dibbled in equal distance and depth. Plants harvests were made on 21, 51 and 95 days. As three harvests were studied a total of 105 pots were maintained and for each harvest a total of 35 pots were taken at random for analysis.

GROWTH PERFORMANCE

Shoot and Root Length

These were measured in cm from the base of the plant to the tip of shoot, in the case of shoot length and from the base of the plant to the tip of the longest root for root length.

Shoot and Root Biomass

The above and belowground parts were separated and dried in hot air oven at 80°C for 24 hr. The plants from each concentration were dried “enmasse” and the average dry weights of shoot and root were calculated. These were presented in grams.

Growth Rate

Estimation of growth rate of crop plants involves addition of positive increment in biomass during a period of

time. The increment of biomass in the present investigation was divided into two categories (a) Mean increment and (b) Relative growth rate (RGR).

R.G.R. (Relative Growth Rate) ($G/G^{-1}/D^{-1}$)

Increment of biomass per unit biomass per unit time was represented as RGR.

$$RGR = \log \frac{W_2 - W_1}{T_2 - T_1} \text{ Where}$$

W_1 = Initial dry weight;

W_2 = Final dry weight; T_1 = Initial Time; T_2 = Final Time.

Total Net Primary Productivity (Tnpp)

Ovington [15] was employed for calculating TNPP where the positive difference in total plant biomass at subsequent sampling dates or harvest days were summed up. NPP was calculated for total plant biomass.

Yield Characters

Fruit length, breadth, weight and number of fruits were measured and yield was calculated in terms of dry weight of fruits per plant.

Chlorophyll Pigments

Chlorophyll-a, Chlorophyll-b and total chlorophylls were estimated following Harborne [16]. Fresh leaf material (200mg) from plants grown in different concentrations of solid waste and that of control was ground in a mortar using 80% acetone in the presence of a pinch of Calcium carbonate. The homogenized material was centrifuged at 300 rpm for 20 minutes. The filtrate was diluted suitably to a known volume (50ml) with 80% acetone without exposing to light. The absorbances of the acetone extract were read at two wavelengths 645 nm and 663 nm using UV visible spectrophotometer against 80% acetone blank. The amount of different chlorophyll fractions was calculated as mg of chlorophyll/g of leaf tissue according to the formula given below

$$\text{Chl - a (mg/g)} = (12.3 A_{663} - 0.86 A_{645}) \times V/100 w$$

$$\text{Chl - b (mg/g)} = (19.3 A_{645} - 3.6 A_{663}) \times V/100 w$$

$$\text{Total Chlorophyll} = (20.2 A_{645} + 8.02 A_{663}) \times V/1000 w$$

Where A = Absorbance of Chlorophyll extract at the specified wave length.

V = Final volume of 80% Chlorophyll extract and

W = Fresh weight of leaf tissue in gm

Plant Metal Analysis

Oven dried (80°C) plant material was finely powdered in an agate mortar and used for the analysis of different heavy metals. Statistical analysis also included.

RESULTS & DISCUSSIONS

The seeds of one variety of Brinjal, *Solanum melongena* L., were tested to evaluate their sensitivity to ISW water extract. However, the germination success in Brinjal declined steeply with the increased concentrations of the WE. The percent of seeds germinated has declined from 99% in the Control to as low as 53% in WE₄. The Industrial solid waste recorded high concentrations of Copper (20.89%), Zinc (16.50%), Iron (9.842%) and Manganese (0.310%). In the present investigation plants grown on Industrial sludge exhibited a decrease in root length and root dry weight. Further the roots and shoots of the plants grown in soils treated with Industrial sludge exhibited an increase in Cu, Zn, Fe and Mn decrease in phosphorous and potassium concentration. In the present study, concentrations of Cu, Zn, Iron and Manganese in root system and significant reduction in the root lengths of plants grown A₁, A₂, A₃ and A₄ over C soils indicate. Inhibitory effect on the root growth has increased with harvest time and decreased from A₁ to A₄ suggesting the possible direct relation between root growth.

Effects on Root Biomass

The accumulation of Copper, Zinc, Iron Manganese in the roots of Brinjal has reduced the root biomass. The root biomass has registered a decrease in the soil amends. The degree of the root biomass decline in different amends with the age of crop and a comparison with control soils is presented below Table -2.

Effects on Shoot Length and Shoot Biomass

The Shoot length and Shoot biomass have decreased in the soil amends. Even within the same amendment, the inhibitory effect on growth of Shoot length and biomass has increased with the age of the crop plant. The decrease in Shoot length and Shoot biomass was inversely proportional to the Copper, Zinc, Iron and Manganese concentrations in the soils amended with ISW.

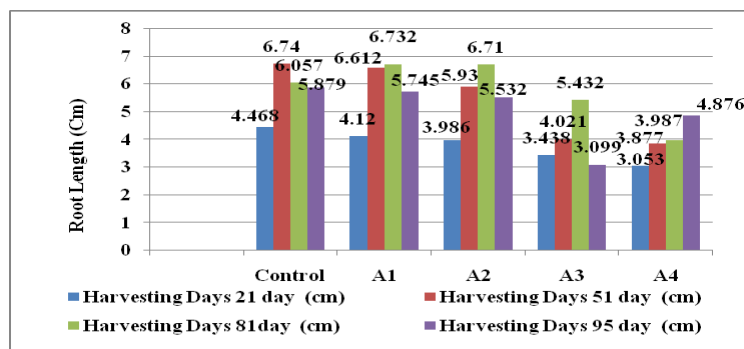


Figure 2: Root Length Grown in Soils Amended with ISW

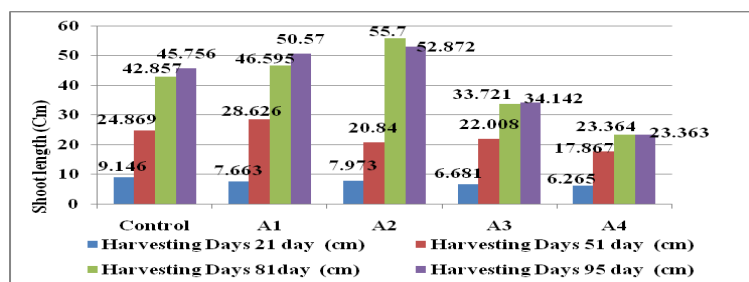


Figure 3: Shoot Length Grown in Soils Amended with ISW

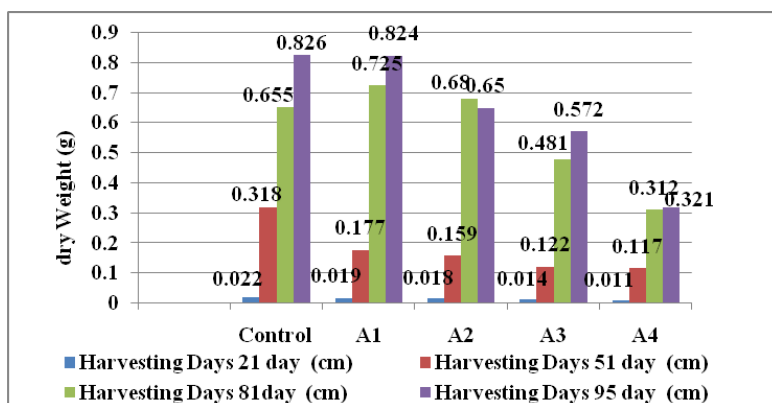


Figure 4: Root Biomass Grown in Soils Amended with ISW

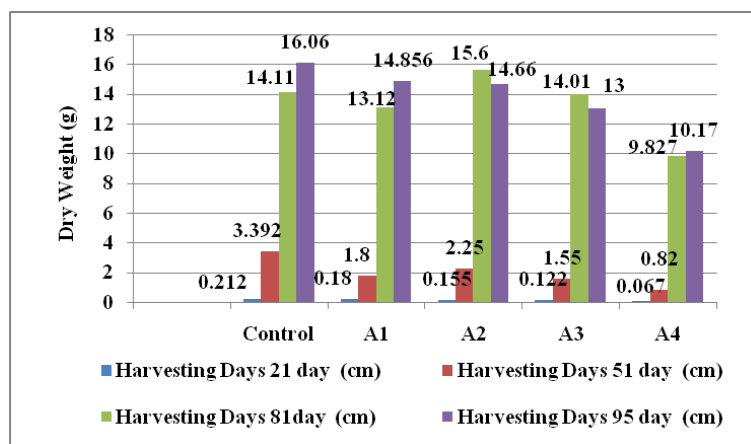


Figure 5: Shoot Biomass Grown in Soils Amended with ISW

Table 1: Mean Decline of Root Length with Amendment

S. No	Amendment	Mean Decline in Root Length (Cm)			
		C To A _x on Day 21	C To A _x on Day 51	C To A _x on Day 81	C To A _x on Day 95
1	A ₁	0.348	0.128	0.675	0.134
2	A ₂	0.482	0.810	0.653	0.347
3	A ₃	1.030	2.719	0.625	2.780
4	A ₄	1.415	2.863	2.070	1.003

Table 2: Mean Decline of Root Biomass with Amendment

S. No	Amendment	Decline in Root Biomass			
		C To A _x on Day 21	C To A _x on Day 51	C To A _x on Day 81	C To A _x on Day 95
1.	A ₁	0.003	0.141	0.070	0.002
2.	A ₂	0.004	0.159	0.025	0.176
3.	A ₃	0.008	0.196	0.174	0.254
4.	A ₄	0.011	0.201	0.343	0.505

Table 3: Mean Decline of Shoot Length with Amendment

S. No	Amendment	Decline In Shoot Length			
		C To A _x on Day 21	C To A _x on Day 51	C To A _x on Day 81	C To A _x on Day 95
1.	A ₁	1.135	2.855	3.063	4.953*
2.	A ₂	0.691	4.029	12.190	7.463*
3.	A ₃	1.435	6.882	8.511	25.164
4.	A ₄	1.256	10.879	17.423	21.390

*Increase over control

Table 4: Mean Decline of Shoot Biomass with Amendment

S. No	Amendment	Decline In Shoot Biomass			
		C To A _x on Day 21	C To A _x on Day 51	C To A _x on Day 81	C To A _x on Day 95
1.	A ₁	0.032	1.592	0.990	1.204
2.	A ₂	0.057	1.142	1.490	1.400
3.	A ₃	0.090	1.842	0.100	3.060*
4.	A ₄	0.145	2.572	4.283	5.890

Effects on Chlorophyll

The reduced availability of essential minerals like Nitrogen, Phosphorous, Potassium, Calcium and Magnesium might have contributed to the decrease in chlorophyll pigments: chlorophyll – a and chlorophyll – b pigments.

Effect on Fruit Yield

The yield of *Solanum* plants declined, both in terms of average number of fruits/plant and average fruit weight. The Industrial Sludge Waste amended soils, considerable reduction in the growth and yield of Brinjal crop (*Solanum melongena* L.) is evident as shown Graph 1

CONCLUSIONS

The presence of higher concentrations of Cu, Zn Fe and Mn in root system and significant reduction over C in root lengths of plants grown in A₁, A₂, A₃ and A₄ soils indicate. The accumulation of Cu, Zn, Fe and Mn in the roots of *Solanum* has also reduced the root biomass. The growth in Shoot length and biomass was inversely proportional to the concentrations of Cu, Zn, Iron and Manganese in the ISW amended soils. A similar trend was observed in case of chlorophyll pigments also. The reduced availability of essential minerals like Phosphorous, Potassium, Calcium and Magnesium might have contributed to the decrease in chlorophyll – a and chlorophyll – b pigments. Higher concentrations of Cu, Zn, Fe and Mn also might have interfered with physiological and biochemical activities in the *Solanum* plants and resulted in low growth and yield at higher concentrations of ISW.

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